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Prohibition on the Placement of Bulk Liquid Hazardous Waste in Landfills Statutory Interpretive Guidance

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PROHIBITION ON THE PLACEMENT OF BULK LIQUID HAZARDOUS WASTE IN LANDFILLS

-STATUTORY INTERPRETIVE GUIDANCE-

June 11, 1986

U. S. ENVIRONMENTAL PROTECTION AGENCY

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Section 3004(c)(1) was added to the Resource Conservation and Recovery Act (RCRA) as amended by the Hazrdous and Solid Waste Amendments of 1984 (HSWA). The amendment prohibits the direct placement of bulk liquid hazardous wastes in a landfill, regardless of the presence of liners and leachate collection and removal systems. The use of materials that function as sorbents are not to be used in the treatment of bulk liquid hazardous wastes that are to be placed in a landfill. The guidance discusses the legal requirements of the amendment and presents technical guidance to assist the owner or operator in complying with the amendment. The use of "absorbents" and "adsorbents" is discussed, along with the concept of chemical stabilization.

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EXECUTIVE SUMMARY

Section 3004 (c)(1) was added to the Resource Conservation and Recovery Act by the Hazardous And Solid Waste Amendments of 1984. This provision states that:

> Effective 6 months after the date of enactment of the Hazardous and Solid Waste Amendments of 1984, the placement of bulk or non-containerized liquid hazardous waste or free liquids contained in hazardous waste (whether or not absorbents have been added) in any landfill is prohibited.

This provision became effective on May 8, 1985. The Agency is issuing this guidance to ensure that owners and operators of hazardous waste landfills regulated under RCRA understand the legal requirements of this provision and to provide technical guidance that will aid owners and operators in complying with the provision.

Section 2 discusses statutory requirements of the provision. The direct placement of bulk liquid hazardous wastes in a landfill is prohibited, regardless of the presence of liners and leachate collection systems. The use of materials that function solely as sorbents are not to be used in the treatment of bulk liquid hazardous wastes that are to be placed in a landfill. Spills cleaned-up by the use of a sorbent material can not be placed directly in a landfill; however, the bulk liquid ban was not intended to encompass soils contaminated by accidental spills into the ground.

Section 3 presents technical guidance to assist the owner or operator in complying with the provision. The following treatment technologies are alternatives for the treatment of bulk liquids:

- liquid-solid separation processes
- biological treatment
- chemical treatment
  - Portland Cement processes
  - pozzolanic processes
- thermal treatment

The use of absorbents and adsorbents is discussed in Section 3. Neither absorption, nor adsorption, is a process that involves a chemical transformation or encapsulation of the sorbed liquid because both are reversible. The Agency interprets the ban on "absorbents" to include materials that sorb wastes through either absorption or adsorption.

Chemical stabilization is an acceptable form of treatment. However, it may be difficult to determine on a case-by-case basis whether a process involves stabilization, or is merely a treatment process involving sorbents. EPA recommends the use of an unconfined compressive strength test to identify true stabilization reactions when it is not obvious that chemical stabilization has taken place. Unconfined compressive strengths above 50 pounds per square inch are characteristic of chemically stabilized wastes; test procedures are discussed in Section 3.

SECTION 1
INTRODUCTION

On November 8, 1984, the Hazardous and Solid Waste Amendments of 1984 were signed into law. Section 3004 (c)(1) addresses bulk liquid hazardous waste in landfills. This provision states that:

> Effective 6 months after the date of enactment of the Hazardous and Solid Waste Amendments of 1984, the placement of bulk or noncontainerized liquid hazardous waste or free liquids contained in hazardous waste (whether or not absorbents have been added) in any landfill is prohibited.

The bulk liquid hazardous waste provision became effective on May 8, 1985. The Agency is issuing this guidance to ensure that owners and operators of hazardous waste landfills regulated under the Resource Conservation and Recovery Act understand the legal requirements of this provision (presented in Section 2 of this guidance) and to provide technical guidance that will aid owners or operators in complying with the provision (presented in Section 3 of this guidance).

SECTION 2
STATUTORY REQUIREMENTS

BULK LIQUID HAZARDOUS WASTES PROHIBITED

Section 3004 (c)(1) calls for an absolute ban after May 8, 1985, on the placement of bulk or non-containerized liquid hazardous waste or free liquids contained in hazardous waste in any landfill that is subject to regulation under Subpart N of 40 CFR Parts 264 and 265. The intent of the provision is to prohibit the direct placement of bulk liquid hazardous wastes into landfills, regardless of the presence of liners or leachate collection and removal systems. The statute makes it clear that the ban encompasses bulk hazardous waste containing free liquids even if absorbents have been added.

The Agency interprets the ban on "placement" of bulk liquid hazardous wastes to include, but not be limited to: 1) placing bulk liquid hazardous wastes into any part of the active landfill unit where the liquids are solidified and then transferred to another part of the active landfill unit, and 2) placing treated bulk liquid hazardous wastes still in liquid form into a landfill cell prior to solidification. The legislative history of a related statutory provision, section 3004(b) (banning the placement of liquid hazardous waste in salt domes, underground mines, or caves) supports the view that Congress intended the ban on "placement" to be construed broadly to prohibit storage of material while awaiting further treatment or disposal, and to preclude use of such locations as treatment chambers (129 Cong. Rec. H8141 (daily ed. Oct. 6, 1983)). Thus, the ban is effective

regardless of the purpose of placing the liquids into a landfill.

In order to comply with this provision, the owner or operator must determine whether a bulk hazardous waste (i.e., non-containerized waste) is a liquid or contains free liquids. EPA regulations define "free liquids" as "liquids which readily separate from the solid portion of a waste under ambient temperature and pressure" (40 CFR Part 260.10). Congress anticipated that EPA would specify an appropriate test for free liquids (see Senate Report No. 284, 98th Cong., 1st Sess. 22 (1983)). EPA believes that the Paint Filter Liquids Test is the appropriate test method to be used to determine the absence or presence of free liquids in both bulk and containerized wastes. On April 30, 1985, EPA promulgated a final rule requiring the use of the Paint Filter Liquids Test (Method 9095). (See 50 FR 18370.) This final rule requires the owner or operator of a hazardous waste landfill to use the Paint Filter Liquids Test to determine whether a bulk hazardous waste is a liquid or contains free liquids, if it is not obviously clear to the owner or operator that the waste does or does not contain free liquids. "Liquids" and "free liquids" subject to this provision include liquids that separate out during transportation to the landfill.

If a sample passes the Paint Filter Liquids Test (i.e., no liquid is detected), the bulk hazardous waste is not subject to the ban in Section 3004 (c)(1) and can be landfilled (assuming no absorbent has been added, as discussed below).

If the sample fails the test, the bulk hazardous liquid waste should be treated prior to landfilling using a treatment technology that does not solely involve the use of a material that functions primarily as an absorbent. These treatment technologies, include, chemical stabilization processes, and are discussed under Treatment Technologies. If, after reviewing a particular stabilization process, it is not obvious that chemical stabilization has taken place (i.e., if there are any concerns that "stabilization" is occurring primarily due to the addition of sorbents), then a representative sample of the treated waste should pass the indirect chemical stabilization test (unconfined compressive strength) as described under Test Method. The purpose of using a chemical stabilization test is to help assure that the treatment of bulk liquids has been accomplished in a manner that does not solely involve the use of a material that functions primarily as an absorbent.

Once it has been demonstrated, where necessary, that a particular stabilization process used for a particular waste will result in a treated product that passes the stabilization test, then samples of each batch would only be required to pass the Paint Filter Liquids Test prior to placement in the landfill. If there are any changes in the treatment process and/or composition of the waste to be treated, stabilization testing should be repeated.

USE OF ABSORBENTS

A major issue raised by the language of Section 3004 (c)(1) is the scope of the prohibition on absorbents. The Agency

is convinced that Congress did not want materials that function solely as absorbents to be used in the treatment of bulk liquid hazardous wastes that are to be placed in a landfill. If Congress had intended to allow any or a certain subset of "acceptable" absorbents to be used in the treatment of bulk liquid hazardous wastes, Congress would have specified this, as it did in the provision concerning the landfilling of containerized hazardous wastes (see Section 3004(c)(2)).

The Agency believes, however, that the term "absorbent" does not include reagents used in: 1) any treatment technology that involves no absorption and produces a bulk solid, or 2) a treatment technology that chemically stabilizes, encapsulates, or solidifies a bulk liquid hazardous waste. EPA believes that Congress was particularly concerned about the use of materials that function solely as absorbents as a treatment method for bulk liquid hazardous wastes in order to force the use of other treatment methods (see Treatment Technologies for preferred treatment methods) and because an absorbent may release the absorbed liquid back to the environment. (See 129 Cong. Rec. H8141 (daily ed. Oct. 6, 1983)). The legislative history to this provision suggests that processes, such as chemical stabilization, which, unlike absorption, render liquids permanently unavailable to the environment, should be deemed appropriate forms of pretreatment of liquid hazardous wastes (129 Cong. Rec. H8141 (daily ed. Oct. 6, 1983)). See also 130 Cong. Rec. S9177 (daily ed. July 25, 1984). Consequently, the Agency interprets the statute to permit the landfilling

of bulk liquid hazardous wastes that have been chemically treated and stabilized so as to contain no free liquids.

If an absorbent material is used to clean up a spill of hazardous waste, this mixture cannot be placed directly in a landfill. The reason, as stated before, is that the language of the statute makes it clear that any liquid hazardous waste, when contained and treated solely by the use of an absorbent, is prohibited from being placed in a landfill in a bulk or non-containerized form. Congress did not specifically exclude spills from the statutory prohibition. If a spill is treated solely by the use of absorbents, the absorbed material may be containerized and placed in a landfill (subject to any EPA regulation relating to absorbents in containers under Section 3004(c)(2)), placed in a surface impoundment, or treated in a manner consistent with this guidance.

Although spills treated with absorbents are subject to the ban on landfilling of bulk liquid hazardous wastes to which absorbents have been added, EPA believes that this ban was not intended to encompass soils contaminated by accidental spills into the ground. The Agency believes, based on the legislative history relating to absorbents, that Congress was primarily concerned about controlling the use of absorbents as a waste management method. See 130 Cong. Rec. S9177 (daily ed. July 25, 1984). There is no evidence that Congress' concern extended to banning the placement in a landfill of soils accidentally contaminated by spills of liquid hazardous waste. In consequence, contaminated soils will be subject

to the same requirements as other hazardous wastes. If the contaminated soil passes the Paint Filter Liquids Test, it will be allowed to be landfilled. If, however, the contaminated soil fails the Paint Filter Liquids Test, then the contaminated soil must be subject to additional treatment as outlined in this guidance.

LOCATION OF MIXING FACILITY

The Agency also believes that in banning the placement of bulk liquid hazardous wastes "whether or not absorbents have been added," Congress intended to ban the placement in a landfill of bulk liquid hazardous wastes that are treated with materials that function solely as absorbents, whether or not the treatment or mixing took place inside or outside the landfill unit. Congress was concerned with the consequences of placing the absorbed liquid wastes into the landfill unit as well as with placing free liquids in the landfill.

In some cases, the generator may have added an absorbent to a bulk liquid hazardous waste. As noted above, the statute bans the placement in a landfill of bulk liquid hazardous wastes if an absorbent was added to the waste regardless of where the absorbent was added. Therefore, EPA believes that an owner or operator has the obligation to determine whether a generator has added a material that functions solely as an absorbent to a waste in order to eliminate free liquids. Owners or operators are not in compliance with the bulk liquids provision if they place bulk liquid mixtures with absorbents in landfills.

The Agency believes that responsibility for compliance

with this provision rests solely with the landfill owner or operator. In developing this approach, the Agency also considered whether responsibility for ensuring compliance with the bulk liquids provision should be shared jointly by the generator and the owner or operator. For instance, if the generators had treatment performed on the bulk liquids, the generators would certify to landfill owners or operators that no absorbents were used. If no treatment was performed, they would certify that no absorbent was added to the waste. The Agency rejected this approach because it was overly burdensome to the generators. As is currently practiced, the off-site landfill owner or operator may enter into a private contractual agreement with generators regarding the use of absorbents in wastes to be landfilled. A contractual agreement, however, will not relieve the landfill owners or operators from their responsibilities to ensure that absorbents were not used in the treatment of the bulk liquids.

SECTION 3

GUIDANCE

GENERAL GUIDANCE

The goal of banning the placement of bulk liquid hazardous wastes in landfills is to reduce the migration of liquid wastes and hazardous constituents. To this end, the preferred methods for managing bulk liquid hazardous wastes are: 1) reduction in liquid waste generation by process design changes (e.g., using less liquid or recirculating rinse water) and by not mixing hazardous wastes with liquids, 2) recycling and recovery (e.g., solvent extraction), 3) treatment by destruction (e.g., incineration), 4) treatment to render the waste or liquid fraction nonhazardous, 5) treatment by removing liquids (e.g., decanting, centrifuge, vacuum drum or conveyor, filter press, distillation, reverse osmosis), and 6) treatment by mixing with agents (e.g., chemical reagents that remove free liquids or chemically transform them into solids). [See 130 Cong. Rec. S9177 (daily ed. July 25, 1984).]

The owner or operator must use the Paint Filter Liquids Test to determine if the bulk hazardous waste is subject to this provision (i.e., the waste is a liquid or contains free liquids). If a hazardous waste fails the Paint Filter Liquids Test, it must be treated before landfilling using a treatment technology that does not involve the use of a material that functions solely as an absorbent. If such treatment is considered chemical stabilization, it may be necessary for a representative sample of the treated waste to pass the chemical

stabilization test if it's not clear that stabilization has occurred before the waste may be landfilled. A bulk liquid that has been treated with an absorbent may also be landfilled in a container if it does not contain free-standing liquids (40 CFR Parts 264.314 and 265.314), subject to any future EPA regulations relating to the use of absorbents in containers.

The Agency believes that the phrase "whether or not absorbents have been added" requires that bulk liquid hazardous wastes intended for disposal in a landfill should first be chemically, thermally, physically, or biologically treated without the use of absorbents. Examples of these treatment technologies were summarized above and are discussed further below. Depending on the treatment technology selected, some bulk liquid hazardous wastes will no longer be placed in landfills while others will be converted to bulk solids that will then be placed into the landfill. The treatment methods listed below are not meant to be all inclusive. Some methods are listed because they are alternatives to the placement of bulk liquid hazardous wastes in landfills (i.e., not all the treatment methods are directed toward the removal of liquids so that the bulk hazardous liquid waste can be landfilled). Of course, the selection of the treatment method should comply with the guidance of this provision.

As stated above, the Agency will exclude from the definition of "absorbent" reagents used in: 1) any treatment technology that involves no absorption and produces a bulk solid, or 2) a

treatment technology that chemically stabilizes, encapsulates, or solidifies a bulk hazardous liquid. The definitions of absorbent and chemical stabilization are presented in the following sections.

It is also important to remember that if the treatment of bulk liquid hazardous wastes occurs in a tank, the treatment unit may be subject to a RCRA permit. If incineration is used, this treatment is regulated under Part 264 or 265, Subpart O. It is also important to remember that the selected treatment method (e.g., mixing) must not occur within the landfill unit.

ABSORBENTS

The Agency classifies an absorbent as a material that is capable of holding a liquid throughout the body of the absorbing material. In an absorbent, the liquid penetrates into the inner structure of the absorbing material. In many absorbents, the volume of the absorbing material increases (i.e. swells) as liquid is absorbed into the body of the absorbent. The use of a material that functions primarily as an absorbent is prohibited as a means of treatment for bulk liquid hazardous wastes if the absorbed mixture is to be placed in a landfill.

The literature is confusing on the use of the terms absorbent and adsorbent. While absorption relies on liquid penetration into the inner structure (i.e., within the void spaces between solid particles) of the material, adsorption is a process where the liquid or gas adheres to the surface of the adsorbing material. Adsorption is the result of intermolecular attractive

forces between the adsorbent and the adsorbed gas or liquid. The liquid is thus distributed over the surface of the adsorbing material in a layer that is only one atom or molecule thick. A material must have a high ratio of surface area to mass to be an effective adsorbent. The intermolecular forces of attraction are normally weak, and the phenomenon is therefore readily reversible. In rare instances, however, a chemical interaction between the adsorbent and the adsorbed substance may occur. In this process, known as chemisorption, a chemical reaction occurs resulting both in a molecular change in the adsorbed material, and much stronger intermolecular forces than are found with simple adsorption. This process is addressed later in this guidance.

While the differences between absorption and adsorption are easily defined on paper, it is much more dfficult to determine whether a particular material acts as an absorbent or adsorbent. Standard test methods exist for determining the holding power of materials, but these methods do not identify the holding mechanism (i.e. absorption or adsorption). In reality, most materials are capable, to various extents of holding materials by both mechanisms.

In keeping with the intent of Congress, however, it is not important to identify if absorption, adsorption, or both are occurring, since neither process involves a chemical transformation or encapsulation of the sorbed liquied (with the exception of chemisorption). Congress is concerned about banning landfill disposal of liquid wastes that have

TREATMENT TECHNOLOGIES

Liquid-Solid Separation Processes

Various liquid-solid separation processes are available to separate the liquid and solid fractions of a bulk liquid hazardous waste. These include such operations as sedimentation or decanting, flotation, filtration (including vacuum filtration), centrifugation, evaporation, and distillation. Sedimentation or decanting is the removal of solid particles suspended in a liquid by gravity settling. Flotation involves the separation of solids from liquids by the attachment of tiny air bubbles to the solid particles. The solid particles with the attached air bubbles then rise to the surface of the liquid, agglomerate there, and are skimmed off. Filtration is the passage of liquids through a fine mesh material that prevents the solid material from passing. Filtration can be enhanced by stirring and by using vacuum or pressure rather than just gravity to cause liquid flow. Vacuum conveyors and drums can be used. Centrifugation separates the solid and liquid components of a waste stream by rapidly rotating the mixture in a vessel. Evaporation is a physical separation process involving vaporization of a liquid from a solution or a slurry. Distillation is evaporation of the more volatile component(s) within a mixture with subsequent condensation to recover the evaporated liquid.

Bulk liquid hazardous wastes can be subjected to such liquid-solid separation processes, or a series of such processes because some processes alone do not completely remove free liquids. The solid residuals can be isolated and then tested

for the presence of free liquids using the Paint Filter Liquids Test. If the solids pass the test, they may be placed into the landfill. If they fail, additional liquid-solid separation processes (or another form of treatment) would be required to remove or eliminate the free liquids. If the liquid fraction isolated from the liquid-solid separation process is a hazardous waste, it is subject to Section 3004(c)(1) and should not be landfilled, unless one of the treatment methods described below is employed. Regardless of whether the waste component is solid or liquid, it is still a hazardous waste unless it is delisted, if it is a listed waste, or no longer meets a characteristic of a hazardous waste. The characteristics of a hazardous waste are given in 40 CFR Parts 261.21 - 261.24.

Biological Treatment

Owners and operators may wish to consider other alternatives to the treatment methods described above. One alternative could be biological treatment. Biological treatment is a generic term applied to processes that use living microorganisms to decompose or detoxify organic wastes into either water, carbon dioxide, non-toxic organics, non-toxic inorganics, or acids and bases. The principal types of conventional biological treatment that might be useful for the treatment of bulk liquid hazardous wastes are:

- activated sludge systems
- trickling filters
- aerated lagoons
- waste stabilization ponds

These treatment methods typically occur in tanks or surface

impoundments. These hazardous waste units are subject to regulation under Subparts J and K, respectively, of 40 CFR Parts 264 and 265.

Thermal Treatment

Another alternative is thermal treatment. The treatment of many non-aqueous bulk hazardous liquids (e.g., solvents and other organics) can be achieved with high temperature destruction. The goal of thermal destruction processes is the oxidation of hazardous waste to water, carbon dioxide, aldehydes, acids, etc. Various thermal destruction methods can be considered, such as:

- o liquid injection incineration
- o rotary kiln incinerators
- o multiple hearth incinerators

Units used for such treatment are subject to regulation under Subpart O of 40 CFR Parts 264 and 265.

Chemical Treatment

Chemical stabilization is a method that may be used to treat bulk hazardous liquids prior to landfilling. The majority of the chemical stabilization techniques in use today: 1) chemically react with the waste to transform free liquids into solid or gel-like materials, 2) result in the production of either a soil-like or clayey material, a thick sludge, a monolithic block with high structural integrity, or a gel-like material with high plasticity, and 3) have the additional benefit of limiting one or more of the following: mobility, solubility, and toxicity. Stabilization usually involves the addition of materials that ensures that the liquid portion

of the waste is chemically transformed into a solid and that the hazardous constituents are maintained in their least soluble and/or least toxic form. In general, higher quantities of stabilization additives result in a more solid product having higher strength and greater stability.

Sorption of a liquid is not the same as chemical stabilization. Sorption is a physical process that may often be reversed, whereas stabilization involves a physical and chemical reaction between the liquids and waste constituents and the stabilizing reagents.

Examples of the most commonly used stabilization technologies are Portland cement-based and pozzolanic processes. The cement-based process is especially effective for wastes with high levels of toxic metals, because at the pH of the cement mixture, most multivalent cations are precipitated as hydroxide or carbonate minerals of very low solubility. The Portland cement-based process is also effective in removing liquids because the reaction of the anhydrous cement powder and water (liquids) incorporates the water into the solid mineral species. The reaction first produces a colloidal calcium-silicate-hydrate gel of indefinite composition and structure. Hardening of the cement is brought about by the interlacing of thin, densely-packed, silicate fibrils growing from the individual cement particles.

Waste stabilization techniques based on lime products (as opposed to Portland cement) usually depend on the reaction of lime with a fine-grained siliceous (pozzolanic) material

and water to produce a solid that is sometimes referred to as pozzolanic cement. The most common pozzolanic materials used in waste treatment are fly ash, ground blast-furnace slag, and cement kiln dust.

The stabilized waste product from both cement-based and pozzolanic processes can vary in consistency from a weak soil-like or clay-like material to a hard, concrete-like mass. The consistency depends on a variety of factors including waste type, moisture content, organic content, and the type and amount of stabilization additives used.

These chemical stabilization techniques require a thorough knowledge of the chemistry of the wastes and treatment reagents. In many cases, special proprietary reagents (usually polymers) are added. This is often required to control the adverse effects of organic compounds on the cementation process. Cement and pozzolanic stabilization may be ineffective in treating many organic compounds. The treatment must be conducted in a well-controlled procedure that employs sophisticated quality control/quality assurance methods. This treatment typically occurs within specially designed vessels, using special apparatus to control the addition and blending of reagents. The units in which these processes occur are typically classified as tanks; these would generally be subject to regulation under Subpart J of 40 CFR Parts 264 and 265. These tanks could be situated in the landfill provided that both the tank and the landfill are regulated in accordance with applicable standards.

TEST METHOD

Because it is often difficult to determine whether a particular process involves stabilization, or is merely absorption, EPA expects owners and operators using a chemical stabilization process to demonstrate that the chemical transformations described above occur. Laboratory data showing that an appropriate "recipe" has been developed and used, plus a demonstration that stabilization has occurred may be necessary in cases where there is a question of whether a particular process actually involves stabilization rather than sorption. Descriptions of the treatment apparatus and quality control methods should also be available, and provided with permit applications.

To aid owners or operators in demonstrating that chemical stabilization has occurred, the Agency is recommending a testing scheme as shown in Exhibit 1. Under this method, any bulk hazardous waste (i.e., no sorbents added) that may contain free liquids is subject to the Paint Filter Liquids Test. If the waste passes the test, it is not subject to the ban (i.e. it can be disposed in a landfill). If the waste fails the test, it may then be treated by a chemical stabilization process prior to landfill disposal. (NOTE: It may be determined that one of the other waste treatment methods described in Treatment Technologies is preferred.) If the waste is treated using a chemical stabilization process, and if it is not obvious that true chemical stabilization has occurred (i.e., if it is suspected that a material that functions solely as a sorbent has been used), then a representative sample of

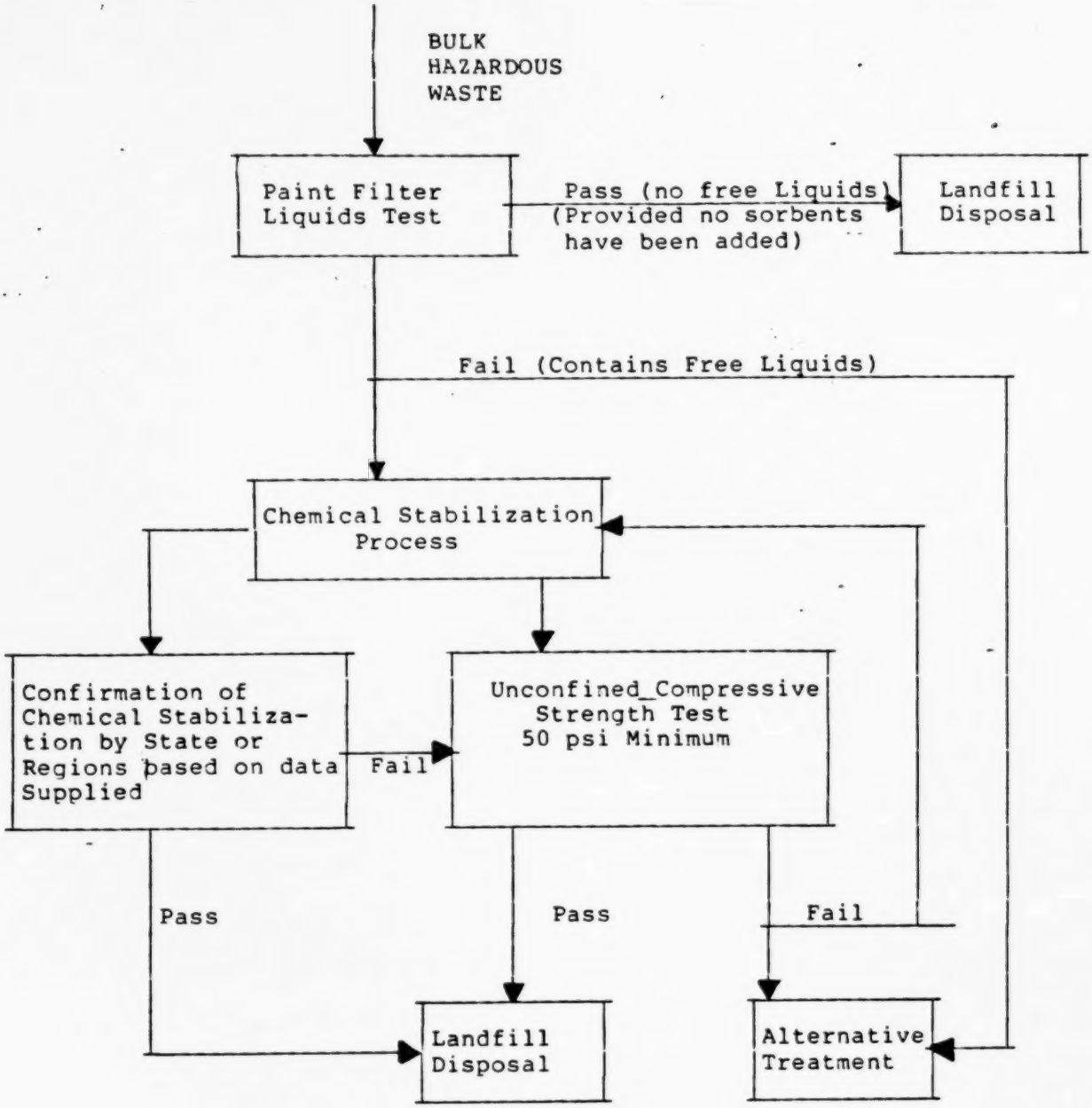

EXHIBIT 1

Bulk Liquid Testing Procedures

the waste should then pass the chemical stabilization test before it can be disposed in a landfill.

Once it has been demonstrated that a particular process used for a particular waste will result in a treated product that passes the stabilization test, then samples of each batch would only be required to pass the Paint Filter Liquids Test prior to placement in the landfill. If there are any changes in the treatment process and/or composition of the waste to be treated, stabilization testing should be repeated.

A wide range of tests were considered for determining if chemical stabilization has occurred. Tests exist that determine whether or not a chemical reaction has taken place. However, these tests are specific to the reacting materials. The wide range of wastes and treatment processes results in an essentially unmanagable number of these confirmatory tests for chemical reactions.

Rather than proposing a series of chemical analyses tests, it is desired to have a single test method that can be used for all types of wastes. The unconfined compressive strength test is proposed as an indirect method for determining the stability of treated waste products. If the owner or operator wishes to use a different method to show that chemical stabilization rather than sorption has occurred, this information should be provided with the facility's Waste Management Plan (for Interim Status Units) or the hazardous waste permit application.

As previously discussed, chemical treatment methods that solidify liquid wastes typically result in either cemented

masses comparable to concrete or discrete particles and low strength mixtures such as sand, soil, weak clay, or sawdust. The most common of these processes are cement-based and pozzolanic processes. It is known that these reactions produce a product having greater strength than the original materials. Compressive strength can therefore be used as an indirect measure of the extent of chemical stabilization when these methods are used to treat liquid wastes.

It is highly desirable to have a single compression test that could be used for most of these stabilized wastes, regardless of the specific waste type or stabilization process used. It is also desired that the test be performed with unconfined samples. Unconfined tests can be performed only on cohesive materials. Since the addition of sorbents generally results in a non-cohesive product, the use of the unconfined test will help assure that wastes treated solely by sorbents are not placed in the landfill.

The unconfined compressive strength test should be modeled on ASTM D2166-85, Unconfined Compressive Strength of Cohesive Soil. The selection of the unconfined compressive strength test, based on soil testing methodology, is aimed at the cemented or pozzolanic class, but is very applicable to the stiffer, less ductile plastics. A minimum allowable strength is selected as the measure of adequate bonding. The minimum strength recommended is 50 psi. The rationale for selecting this value is an effort to require a bonding level in excess of that achieved with sorbents. The electrostatic and surface

tension bonding that is present in most of these materials is most strongly present in very stiff clays. For comparative purposes, the compressive strengths of a variety of materials are shown in Exhibit 2. As shown in Exhibit 2, very stiff clays typically have unconfined compressive strengths of 28 to 57 psi. It is felt that a compressive strength limit nearer the high end of this range will assure that chemical bonding, and not just absorption or adsortion, is present. The 50 psi minimum compressive strength limit should also assure that the treated waste has at least as much strength as the soil surrounding the disposal site.

The second common class of products resulting from stabilization processes are the low strength soil-like and clay-like materials, including cohesionless sandy products. If it is not apparent that the process is indeed "stabilization" then it would be necessary to use the unconfined compressive strength test. However, further treatment may be necessary to achieve the 50 psi limit, however, the amount of treatment is expected to be minimal.

In an attempt to predict how easily various types of soils or soil-like wastes could be treated to increase their unconfined compressive strengths, the results of a series of soil-stabilization studies are presented [8]. These studies were performed using nine different soil types. Prior to the addition of stabilization compounds, test specimens were molded according to ASTM D1632-63: Standard Method of Making and Curing Soil-Cement Compression and Flexure Test Speciments in the Laboratory. After seven days of controlled storage, the unconfined compressive

EXHIBIT 2. COMPRESSIVE STRENGTH DATA (PSI)

Material	Compressive Strength	Reference
BRICK		
Grade SW	3,000	1
Grade MW	2,500	1
Grade NW	1,500	1
CERAMICS, GLASS, CARBON		
Alumina Ceramics	350,000	2
Carbon, Coal based	1,700-2,400	3
Carbon, Petroleum based	6,300-9,000	3
Industrial Graphite	1,900-8,500	3
Polycrystalline Glass	50,000	3
Porcelain	60,000-90,000	4
Stoneware	40,000-80,000	4
Tungsten Carbide	600,000	2
CLAY (UNCONFINED)		
Very Soft	Less than 3.6	5
Soft	3.6 to 7.1	5
Medium	7.1 to 14	5
Stiff	14 to 28	5
Very Stiff	28 to 57	5
Extremely Stiff	Over 57	5
CONCRETE		
Low Strength	2,000	2
Medium Strength	3,000-4,000	2
High Strength	5,000	2
METALS		
Cast Iron, grey	120,000	6
PLASTICS AND ELASTOMERS		
Acrylics, cast	12,000-18,000	7
Cellulose Acetate, molded	20,000	2
Epoxy, amine	4,000	4
Epoxy, general purpose	30,000	2
Epoxy, polyamide	6,000	4
Nylons	2,400-9,700	3
Phenolics, cast, type 1	14,000-18,000	7
Phenolics, molded, general purpose	30,000	2
Polyester, cast, rigid	12,000-37,000	3
Polyester, cast, flexible	1,000-17,000	3
Polypropylene	5,500-6,500	3
Polystyrene, general purpose	14,000	2
Polytetrafluoroethylene (Teflon)	700-1,800	3
Silicone, cast, type 1	14,000-18,000	7
STONE		
Granite	13,000-55,000	1
Limestone	2,500-28,000	1
Marble	8,000-27,000	1
Sandstone	5,000-20,000	1
Slate	9,000-10,000	1

strength of each soil type was measured according to ASTM D1633-63: Test for Compressive Strength of Molded Soil-Cement Cylinders. The results, shown in Exhibit 3, indicate strengths ranging from 26 to 56 psi. All values in Exhibit 3 are the average of three specimens.

Samples of each of the nine soil types were then mixed with simple stabilization compounds. Two different stabilization additives, cement and lime, were used for each soil type. The cement additive consisted of a blend of three brands. The lime consisted of a blend of two brands. For each additive, two different quantities, 3 percent and 5 percent, were used, resulting in four different mixtures for each soil type.

Specimens were prepared in accordance with ASTM D1632. Specimens were molded either immediately after machine mixing of the soil/additive blend (denoted as no compaction in Exhibit 3) or after a 24-hour delay. During the delay, the material was stored at 73 degrees F. Any moisture lost during the delay was replaced. The materials were remixed prior to molding.

The results of the unconfined compressive strength tests for both the no-delay and 24-hour delay specimens appear in Exhibit 3. Final strength increase, as measured against the strength of the untreated soils, ranges from 56 percent to 1,800 percent. It is especially important to note that small additions of either cement or lime yielded dramatic increases in compressive strength of soils. Increases of

EXHIBIT 3. UNCONFINED COMPRESSIVE STRENGTHS (PSI)

Soil Number	Additive	No Compaction Delay			24-Hr. Compaction Delay	
		7-day Strength	28-day Strength	90-day Strength	7-day Strength	28-day Strength
1	None	56	..	..	..	..
	3% Cement	98	135	189	83	128
	3% Lime	76	128	155	86	143
	5% Cement	160	233	311	135	207
	5% Lime	120	190	274	132	193
2	None	26	..	..	..	..
	3% Cement	316	374	..	243	324
	3% Lime	80	136	..	75	117
	5% Cement	445	495	..	270	371
	5% Lime	103	161	..	84	138
3	None	29	..	..	..	..
	3% Cement	216	277	..	179	238
	3% Lime	89	153	..	95	146
	5% Cement	332	426	..	256	320
	5% Lime	115	174	..	121	192
4	None	28	..	..	..	..
	3% Cement	210	269	..	141	185
	3% Lime	64	117	..	58	103
	5% Cement	323	414	..	234	302
	5% Lime	111	171	..	98	184
5	None	41	..	..	..	..
	3% Cement	124	149	..	100	133
	3% Lime	78	97	..	81	114
	5% Cement	172	232	..	158	213
	5% Lime	95	164	..	93	175
6	None	26	..	..	..	..
	3% Cement	234	276	..	156	267
	3% Lime	116	184	..	88	166
	5% Cement	405	452	..	217	346
	5% Lime	137	204	..	101	193
7	None	37	..	..	..	..
	3% Cement	158	202	..	135	192
	3% Lime	149	184	..	174	221
	5% Cement	243	310	..	219	283
	5% Lime	172	260	..	198	292
8	None	54	..	..	..	..
	3% Cement	114	158	254	84	140
	3% Lime	98	150	218	103	143
	5% Cement	174	234	379	141	205
	5% Lime	111	216	313	145	252
9	None	38	..	..	..	..
	3% Cement	147	186	240	107	137
	3% Lime	131	234	270	118	166
	5% Cement	237	377	466	204	294
	5% Lime	175	292	369	202	322

Source: [8]

All compressive strengths are the average of three specimens.

two-fold to fourteen-fold resulted from the addition of only 3 percent cement. The unconfined compressive strengths of the soils treated with lime also appear in Exhibit 3. These strengths range from 76 psi to 369 psi. The strength increase, as measured against the strength of the untreated soils, ranges from 36 percent to 870 percent. Again, it is important to note that the addition of only 3 percent or 5 percent lime results in a dramatic increase in the unconfined compressive strength.

These studies show that the recommended 50 psi unconfined compressive strength limit is easily attainable for soil-like products. The addition of minimal amounts of cement or lime can be used. All of the soils treated with 3 percent cement exceeded the 50 psi criteria within 7 days. All of the soils treated with 3 percent lime also reached the criteria within the 7 days. The compressive strengths of all of the tested soils were even greater after 28 days. Changes in product strength as a function time are further discussed in the following section.

TIME FACTOR

The Agency knows that time is necessary for complete and final chemical stabilization to occur. This time has been stated to be from several hours to 7 days or more, depending on the waste type and treatment process used. As noted earlier, EPA interprets the statutory language as banning the placement of treated bulk liquid hazardous wastes in a landfill prior to the treated material passing the Paint

Filter Liquids Test. Unconfined Compressive strength testing, when necessary, should be performed in advance for each waste to be treated by a particular process. This preliminary testing will identify the acceptable cure times required for a stabilized waste to meet the 50 psi limit.

This guidance does not contain a list of acceptable stabilization materials because a material may be both a sorbent and an ingredient in a stabilization process. General technical reference information on chemical stabilization methods is available in the Guide to the Disposal of Chemically Stabilized and Solidified Waste (EPA, 1982). This is available from the U.S. Government Printing Office, Washington, D.C. 20401 under stock number 055-000-00226-6, for $6.00.

IMPLEMENTATION

Process changes at some facilities with hazardous waste landfills may be necessary in order to comply with this statutory prohibition. These process changes may be in the form of additional storage or treatment units. Section 270.72 allows changes in the processes for the treatment or storage of hazardous waste at the facility or the addition of other units if the owner or operator submits a revised Part A permit application to EPA (or an authorized State) prior to such a change along with justification explaining the need for the change and the Regional Administrator (or the Director of the State agency in an authorized State) approves such a change. The Regional Administrator (or the Director of the State agency in an authorized State) may

approve such changes because they will be necessary to comply with this new statutory requirement.

REFERENCES

1. Baumeister, T., E.A. Avallone, and T. Baumeister III, Editors, Marks' Standard Handbook for Mechanical Engineers, Eighth Edition, McGraw-Hill Book Company, New York, 1978, pp. 6-149 to 6-159.

2. Richards, C.W., Engineering Materials Science, Wadsworth Publishing Company, Inc., Belmont, California, 1961, pp. 518-521.

3. Materials Selector 76, Materials Engineering Magazine, 82(4), Mid-September, 1976.

4. Perry, R.H. and D.W. green, Editors, Chemical Engineers' Handbook, Sixth Edition, McGraw-Hill Book Company, New York, 1984, pp. 23-58 to 23-62.

5. Terzaghi, K., and R.B., Peck, Soil Mechanics in Engineering Practice, John Wiley and Sons, New York, 1948, p. 31.

6. Popov, E.P., Mechanics of Materials, Second Edition, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1976, page 570.

7. Perry, R.H., and C.H. Chilton, Editors, Chemical Engineers' Handbook, Fifth Edition, McGraw-Hill Book Company, New York, 1973, pp. 23-62.

8. Christensen, A.P., Cement Modification of Clay Soils, Portland Cement Association, 1969.